

Technical Support Document for Exposure Assessment and Stochastic Analysis
September 2000

Air Toxics “Hot Spots” Program Risk Assessment Guidelines Part IV

Technical Support Document
for
Exposure Assessment and Stochastic Analysis

September 2000

Table of Contents

Table of Contents	i
Executive Summary.....	ES-1
Section 1: Introduction	
1. Introduction.....	1-1
1.1 Multipathway Nature of Exposure Assessment	1-2
1.2 The Point Estimate Approach	1-4
1.3 The Stochastic Approach (“Likelihood of Risks” Approach).	1-6
1.4 Tiered Approach to Risk Assessment	1-8
1.4.1 Tier 1	1-8
1.4.2 Tier 2	1-10
1.4.3 Tier 3	1-10
1.4.4 Tier 4	1-11
1.5 Exposure Assessment Pathways	1-12
1.6 References.....	1-13
Section 2: Air Dispersion Modeling	
2.1 Air Dispersion Modeling in Risk Assessment: Overview	2-1

Technical Support Document for Exposure Assessment and Stochastic Analysis
September 2000

2.2 Emission Inventories.....	2-3
2.2.1 Air Toxics “Hot Spots” Emissions	2-3
2.2.1.1 Substances Emitted	2-3
2.2.1.2 Emission Estimates Used in Risk Assessment	2-4
2.2.1.3 Release Parameters	2-5
2.2.1.4 Operation Schedule.....	2-5
2.2.1.5 Emission Controls.....	2-5
2.2.2 Landfill Emissions	2-5
2.3 Source Characterization	2-6
2.3.1 Classification According to Source Type	2-6
2.3.1.1 Point Sources	2-6
2.3.1.2 Line Sources.....	2-6
2.3.1.3 Area Sources	2-6
2.3.1.4 Volume Sources.....	2-7
2.3.2 Classification According to Quantity of Sources.....	2-7
2.4 Terrain Characterization	2-8
2.4.1 Classification According to Land Type	2-8
2.4.1.1 Land Use Procedure	2-8
2.4.1.2 Population Density Procedure.....	2-8
2.4.2 Classification According to Terrain Topography	2-10
2.4.2.1 Simple Terrain (also referred as “Rolling Terrain”)	2-10
2.4.2.2 Intermediate Terrain.....	2-10
2.4.2.3 Complex Terrain	2-10
2.5 Level of Detail: Screening vs. Refined Analysis	2-10
2.6 Population Exposure	2-11
2.6.1 Zone of Impact.....	2-11
2.6.2 Population Estimates for Screening Risk Assessments	2-12
2.6.3 Population Estimates for Refined Risk Assessments	2-12
2.6.3.1 Census Tracts	2-13
2.6.3.2 Subcensus Tract	2-14
2.6.4 Sensitive Receptor Locations.....	2-14
2.7 Receptor Siting.....	2-15
2.7.1 Receptor Points	2-15
2.7.2 Centroid Locations.....	2-15
2.8 Meteorological Data.....	2-16
2.8.1 Meteorological Data Formats.....	2-17
2.8.2 Treatment of Calms.....	2-18

Technical Support Document for Exposure Assessment and Stochastic Analysis
September 2000

2.8.3 Treatment of Missing Data	2-18
2.8.4 Representativeness of Meteorological Data.....	2-19
2.8.4.1 Spatial Dependence.....	2-19
2.8.4.2 Temporal Dependence	2-20
2.8.4.3 Further Considerations.....	2-20
2.8.5 Alternative Meteorological Data Sources	2-21
2.8.5.1 Recommendations.....	2-21
2.8.6 Quality Assurance and Control	2-22
2.9 Model Selection	2-22
2.9.1 Recommended Models.....	2-23
2.9.2 Alternative Models.....	2-25
2.10 Screening Air Dispersion Models	2-25
2.10.1 SCREEN3	2-26
2.10.2 Valley Screening	2-28
2.10.3 CTSCREEN	2-29
2.10.4 SHORTZ.....	2-30
2.10.5 LONGZ	2-30
2.10.6 RTDM	2-31
2.11 Refined Air Dispersion Models	2-33
2.11.1 ISCST3.....	2-33
2.11.1.1 Regulatory Options	2-33
2.11.1.2 Special Cases	2-34
2.11.2 RAM	2-35
2.11.2.1 Regulatory Application	2-35
2.11.5 CTDMPLUS	2-36
2.12 Modeling Special Cases.....	2-36
2.12.1 Building Downwash.....	2-36
2.12.2 Deposition	2-37
2.12.3 Short Duration Emissions	2-38
2.12.4 Fumigation	2-38
2.12.5 Raincap on Stack.....	2-39
2.12.6 Landfill Sites	2-40
2.13 Specialized Models	2-40
2.13.1 Buoyant Line and Point Source Dispersion Model (BLP).....	2-40
2.13.1.1 Regulatory Applications	2-40
2.13.2 Offshore and Coastal Dispersion Model (OCD).....	2-41
2.13.2.1 Regulatory Applications	2-41
2.13.3 Shoreline Dispersion Model (SDM)	2-41
2.14 Interaction with the District	2-41

Technical Support Document for Exposure Assessment and Stochastic Analysis
September 2000

2.14.1 Submittal of Modeling Protocol	2-42
2.15 Report Preparation	2-44
2.15.1 Information on the Facility and Its Surroundings.....	2-44
2.15.2 Source and Emission Inventory Information.....	2-44
2.15.3 Exposed Population and Receptor Location.....	2-45
2.15.4 Meteorological Data.....	2-46
2.15.5 Model Selection and Modeling Rationale.....	2-46
2.15.6 Air Dispersion Modeling Results.....	2-47
2.16 References.....	2-48
Section 3: Daily Breathing Rates	
3.1 Introduction.....	3-1
3.1.1 Point Estimate Approach to Inhalation Cancer Risk	3-2
3.1.2 Stochastic Approach to Inhalation Dose and Cancer Risk	3-2
3.2 Methods for Estimating Daily Breathing Rates	3-3
3.2.1 Time-weighted Average Ventilation Rates.....	3-3
3.2.2 Estimates Based on Caloric Intake or Energy Expenditure	3-4
3.2.3 Current Default Values	3-5
3.3 Available Data on Breathing Rates	3-5
3.3.1 Compilations of Ventilation Rate Data.....	3-5
3.3.2 Layton (1993).....	3-7
3.3.3 Adams (1993)	3-8
3.3.4 Linn et al. (1993).....	3-10
3.3.5 U.S. EPA Draft Exposure Factors Handbook (1997)	3-11
3.4 Ranges of Ventilation Rates.....	3-13
3.5 Use of Activity Patterns and Ventilation Rate Data to Develop Breathing Rate Distribution	3-20
3.5.1 CARB Sponsored Activity Pattern Studies.....	3-20
3.5.2 Development of Daily Breathing Rate Distribution.....	3-20
3.5.3 Evaluating the Validity of the Breathing Rate Distributions	3-34
3.6 Recommendations.....	3-37
3.6.1 The Point Estimate Approach	3-37
3.6.2 The Stochastic Approach	3-38
3.7 References.....	3-39

Section 4: Soil Ingestion Rates

4.1 Introduction.....	4-1
4.1.1 Incidental Soil Ingestion	4-1
4.1.2 Intentional Soil Ingestion	4-1
4.2 Current CAPCOA Algorithm for Dose from Soil Ingestion.....	4-2
4.3 Proposed Algorithm for Dose via Soil Ingestion	4-2
4.3.1 Inadvertent Soil Ingestion by Adults.....	4-2
4.3.2 Inadvertent Soil Ingestion by Children	4-3
4.3.3 Inadvertent Soil Ingestion by Offsite Workers	4-3
4.4 Soil Ingestion Studies	4-4
4.4.1 Studies in Children.....	4-4
4.4.1.1 Binder et al. (1986)	4-4
4.4.1.2 Clausing et al. (1987)	4-5
4.4.1.3 Van Wijnen et al. (1990).....	4-6
4.4.1.4 Davis et al. (1990).....	4-6
4.4.1.5 Calabrese et al. (1989)	4-7
4.5 Studies in Adults - Calabrese et al. (1990)	4-9
4.6 Distributions of Soil Ingestion Estimates	4-9
4.6.1 Thompson and Burmaster (1991)	4-9
4.6.2 AIHC (1994) and Finley et al. (1994)	4-9
4.6.3 Stanek and Calabrese (1995a).....	4-10
4.6.4 Stanek and Calabrese (1995b)	4-13
4.6.5 Summary of Utility of Existing Distributions to Air Toxics Hot Spots Program....	4-14
4.7 Recommendations.....	4-14
4.7.1 Incidental Soil Ingestion by Children	4-14
4.7.3 Incidental Soil Ingestion by Adults.....	4-15
4.7.4 Intentional Soil Ingestion (pica) by Children.....	4-15
4.8 References.....	4-16

Section 5: Breast Milk Consumption Rate

5.1 Introduction	5-1
5.5.1 Terminology	5-1
5.1.2 Existing Guidance and Reports.....	5-2
5.1.3 Conceptual Framework for Considering Variable Breast Milk Consumption Rate ..	5-5
5.2 Breast Milk Consumption Among Breast-feeding Infants	5-6

Technical Support Document for Exposure Assessment and Stochastic Analysis
September 2000

5.2.1 Literature Review and Evaluation of Breast Milk Consumption Studies.....	5-6
5.2.1.1 Measurement of Volume of Breast Milk Consumed.....	5-8
5.2.1.2 Correlation with Age and Body Weight.....	5-8
5.2.1.3 Insensible Water Loss.....	5-8
5.2.1.4 Effect of Maternal Factors on Breast Milk Intake.....	5-8
5.2.2 Study Selection for Analysis of Milk Consumption Rates	5-9
5.2.2.1 Study Selection.....	5-9
5.2.2.2 Descriptions of Selected Studies.....	5-9
5.2.3 Data Analyses and Derivation of Distributions of Breast Milk Consumption Rate.....	5-10
5.2.4 Comparison to Results Reported for other Breast Milk Intake Studies.....	5-13
5.2.5 Annual Average Intake for Exclusively versus Fully Breast Fed Infants	5-15
5.2.6 Effect of solid food introduction and weaning on estimates of breast milk intake	5-16
5.2.7 Representativeness of estimates of breast milk consumption.....	5-16
5.3 Breast Milk Consumption in the General Population	5-17
5.3.1 Duration of Breast Feeding.....	5-17
5.3.2 Distribution of Breast Milk Intake Among the Entire Infant Population.....	5-18
5.4 Lipid Concentration and Distribution of Lipid Intake	5-19
5.4.1 Lipid Content of Breast Milk	5-19
5.4.2 Distribution of Lipid Intake	5-20
5.5 Concluding Remarks	5-20
5.5.1 Trends in Breast-feeding	5-20
5.5.2 Subpopulations of Special Concern	5-22
5.5.3 Promotion of Breast-feeding	5-23
5.5.4 Conclusion	5-25
5.6 Recommendations.....	5-25
5.6.1 Default Point Estimate for Daily Breast Milk Consumption During the First Year	5-25
5.6.2 Breast Milk Consumption Among Individuals during the First Year of Life.....	5-26
5.6.3 Consideration of Variable Age of Breast-feeding Mothers	5-27
5.6.4 Analysis for population-wide impacts from breast milk exposure	5-27
5.7 References.....	5-28
Section 6: Dermal Exposure Assessment	6-1
6.1 Introduction.....	6-1
6.2 Factors Providing Significant Variation in Dermal Uptake.....	6-2
6.3. Exposure Factors and Studies Evaluated	6-3

Technical Support Document for Exposure Assessment and Stochastic Analysis
September 2000

6.3.1 Chemical-specific Factors.....	6-3
6.3.2 Concentration and Temperature Dependence of Uptake	6-4
6.3.3 Skin Area Factors.....	6-4
6.3.4 Soil Adherence Factors	6-5
6.3.5 Soil Layer Thickness.....	6-5
6.3.6 Clothing Penetration Values	6-6
6.3.7 Behavioral Factors	6-6
6.4 Dermal Uptake Estimation Equations.....	6-7
6.4.1 U.S. EPA Exposure Estimates (1992, 1995a).....	6-7
6.4.2 Cal/EPA Department of Pesticide Regulation Guidance for the Preparation of Human Pesticide Exposure Assessment Documents (1993)	6-8
6.4.3 CalTOX (1993)	6-8
6.4.4 Frequency of Exposure to Soil.....	6-9
6.5 Recommendations.....	6-9
6.6 References.....	6-12
Section 7: Food Intake.....	7-1
7.1 Introduction.....	7-1
7.2 Algorithm for Food Intake Dose.....	7-1
7.2.1 Point Estimate (Deterministic) Algorithm	7-1
7.2.2 Stochastic Algorithm	7-1
7.3 Methods and Studies Available for Estimation of Per Capita Consumption.....	7-2
7.4 Categorization of Produce.....	7-5
7.5 Produce, Meat, Dairy and Egg Consumption Distributions.....	7-9
7.6 Calculating Contaminant Concentrations in Food.....	7-9
7.6.1 Algorithms used to Estimate Concentration in Vegetation (Food and Feed)	7-10
7.6.1.1 Deposition onto Crops	7-10
7.6.1.2 Translation from the Roots	7-12
7.6.2 Algorithms used to Estimate Dose to the Food Animal	7-13
7.6.2.1 Dose via Inhalation	7-13
7.6.2.2 Dose via Water Ingestion.....	7-14
7.6.2.3 Dose from Feed Ingestion, Pasturing, Grazing	7-14
7.6.2.4 Transfer Coefficients from Feed to Animal Products.....	7-15
7.7 Default Values for Calculation of Food Contaminant Concentration.....	7-18
7.7.1 Body Weight Defaults.....	7-18

Technical Support Document for Exposure Assessment and Stochastic Analysis
September 2000

7.7.2 Breathing Rate Defaults	7-18
7.7.3 Feed Ingestion Defaults	7-19
7.7.4 Water Ingestion Defaults	7-19
7.7.5 Soil Consumption Defaults	7-20
7.8 Summary	7-20
7.9. Recommendations.....	7-21
7.9.1 Point Estimates	7-21
7.9.2 Stochastic Approach	7-21
7.10 References.....	7-22
Section 8: Water Intake.....	8-1
8.1 Introduction.....	8-1
8.2 Empirical Distributions.....	8-2
8.2.1 Exposure Factors Handbook (U.S. EPA, 1997).....	8-2
8.2.2 Ershow and Cantor (1989), Ershow et al. (1991)	8-3
8.2.3 Canadian Study (CEHD, 1981).....	8-9
8.2.4 High Activities and Hot Climates.....	8-9
8.3 Modeled Distributions	8-9
8.3.1 Roseberry and Burmaster (1992)	8-9
8.4 Recommendations.....	8-11
8.4.1 Point Estimate Approach	8-11
8.4.2 The Stochastic Approach	8-12
8.4.2.1 Empirical Western Regional distributions of Ershow & Cantor	8-12
8.4.2.2 Pregnant, Lactating, Breast-fed Subpopulations	8-15
8.4.2.3 High Activities and Hot Climates.....	8-15
8.5 References.....	8-16
Section 9: Fish Consumption	9-1
9.1 Introduction.....	9-1
9.2 Algorithm for Dose via Fish Ingestion	9-2
9.3 Studies Evaluated for Noncommercial Fish Consumption Parameter.....	9-4
9.4 Determination of Fish Consumption Distribution	9-7
9.4.1 Choice of Study.....	9-7

Technical Support Document for Exposure Assessment and Stochastic Analysis
September 2000

9.4.2 Correction for Unequal Sampling Probabilities.....	9-7
9.4.2.1 Calculation Methods	9-7
9.4.2.2 Results for the Santa Monica Bay Study.....	9-9
9.4.2.3 Discussion	9-10
9.5 Statistical Treatment	9-10
9.6 Recommendations.....	9-12
9.6.1 List of Hot Spots Chemicals for which Evaluation of the Fish Pathway is Recommended.....	9-12
9.6.2 Point Estimates of Fish Consumption for Individual Cancer and Noncancer Risk Estimates for Those Who Consume Fisher-Caught Fish.....	9-13
9.6.3 Stochastic Approach to Risk Assessment	9-14
9.6 References.....	9-18
Section 10: Body Weight	10-1
10.1 Introduction.....	10-1
10.2 Empirical Distributions.....	10-1
10.2.1 NHANES II (U.S. EPA, 1989a).....	10-1
10.2.2 Report of the Task Group on Reference Man (ICRP, 1975).....	10-1
10.2.3 NCHS (Hamill et al., 1979)	10-2
10.3 Modeled Distributions	10-2
10.3.1 Brainard and Burmaster, (1992).....	10-2
10.3.2 Finley et al. (1994)	10-2
10.3.3 Burmaster et al. (1977)	10-3
10.4 Recommendations.....	10-6
10.4.1 Point Estimate Approach	10-6
10.4.2 Distributions for Stochastic Approach.....	10-6
10.5 References.....	10-8
Section 11: Exposure Duration	11-1
11.1 Introduction.....	11-1
11.2 Dose Algorithm and Duration of Exposure	11-1
11.3 Available Studies for Evaluating Residency Time	11-3
11.4 Discussion	11-3

Technical Support Document for Exposure Assessment and Stochastic Analysis
September 2000

11.4.1 Problems with Less-than-Lifetime Risk Estimates.....	11-4
11.5 Recommendations.....	11-4
11.6 References.....	11-6

Appendix A: List of Substances

Appendix B: Health and Safety Code Related to Hot Spots Program¹

Appendix C: Produce, Meat, Dairy and Egg Consumption Empirical Distributions (Gm/day)
Comparison of Produce, Meat, Dairy and Egg Empirical Consumption
Distributions (Gm/Kg BW/Day) with Parametric Models

Appendix D: CSFII Food Categories Used to Determine Per Capita Food Consumption

Appendix E: Determination of Chemicals for Multipathway Analysis

Appendix F: Dermal Absorption Factors

Appendix G: Chemical-specific Soil Half Life

Appendix H: Fish Bioconcentration Factors (BCF)

Appendix I: Glossary and List of Acronyms

Appendix J: HRA Forms and Maps Used With Air Dispersion Modeling

Appendix K: Comparison of Breathing Rates Distribution to
Energy Expenditure Information